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Research Note

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
OGDEN, UTAH 84401

USDA Forest Service
Research Note INT-97

1969

POROSITY OF CHEATGRASS FUEL RELATED TO WEIGHT

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ABSTRACT

Porosity (expressed as the ratio of air space surrounding plant material to surface area of plant material) was determined for a low forage producing community of cheatgrass. Porosity averaged 12.5 cm.^{3}/cm.^{2} and correlated closely with weight per square meter. Estimation of porosity from weight per unit of ground area is a practical aid in assessing the flammability of cheatgrass.

Cheatgrass (Bromus tectorum L.) is a finely divided fuel that is highly flammable[2] when dry and can support rapid rates of fire spread (Barrows 1951; Klemmedson and Smith 1964). Because cheatgrass is widely distributed--occurring on at least 60 million acres in the 11 Western States (Hull 1965)--it presents a fire hazard of major concern to many land management agencies. An understanding of the factors controlling cheatgrass flammability is necessary for good management of range and forest lands.

The flammability of cheatgrass depends largely on physical properties, such as weight and porosity, and on moisture content. Porosity refers to the spacing of plant particles and is defined here as the ratio of airspace surrounding plant particles to surface area of these plant particles. The moisture content of uncured cheatgrass is physiologically controlled at a fairly high level, which can be estimated from plant coloration (Mutch 1967). When the moisture content reaches low levels (5- to 10-percent dry weight), variations in flammability probably are primarily caused by fuel weight and porosity.

Porosity is a difficult variable to determine because it requires time-consuming measurements of fuel volume and surface area. A literature search failed to reveal any porosity values for cheatgrass. This study provides such values for several densities of cheatgrass and shows that fuel weight, a relatively easy variable to measure, can be used to estimate porosity with good reliability.

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[2] Flammability is defined as the relative ease with which fuels ignite and burn regardless of the quantity of the fuels. (U.S. Dep. Agr., Glossary of terms used in forest fire control. P. 13, in: Agr. Handbook 104, 24 pp. 1956.)

METHODS AND MATERIALS

An area of approximately 1 acre was sampled in August 1966. The area is on a gentle south-facing slope in northwestern Montana. Three zones containing heavy, moderate, and sparse amounts of cheatgrass were delineated by staking out the boundaries. Study plots, 10 by 25 cm. in size, were located in each zone to assure a wide range in plant densities. The heavy density zone contained 11 plots, the medium zone 20 plots, and the light zone seven plots.

Average height of cheatgrass was measured to the nearest whole centimeter to permit calculation of space occupied by fuel. The general level across the top of the cheatgrass was judged to be the average height. Occasional cheatgrass parts protruding above this level were excluded from the measurements.

All cheatgrass within each plot was carefully clipped, collected, and dissected into six component classes: stalks, leaves, peduncles, glumes, spikelets, and awns. A small amount of plant material, mostly spikelets without glumes, lay partially stuck in the soil and was left as litter. The material in each class was weighed and reduced to an ovendry basis using xylene distillation for determination of the moisture content (Buck and Hughes 1939).

Surface area and volume were measured for a randomly picked subsample of each component in the following manner: for stalks, peduncles, and awns, cross-sectional areas and perimeters were numerically integrated with length; for leaves and glumes, areas from blueprint outlines of flat surfaces were combined with particle thicknesses; for spikelets, both of these techniques were used (Brown 1968). These subsamples were also weighed.

Based upon these measurements, average volume per gram and surface area per gram factors were calculated for each component (table 1). These factors multiplied by total plot weights (grams) of each component yielded component volumes and surface areas that, when summed, gave total plot volume and surface area values. Porosity of each plot was then calculated from

$$\frac{(\text{Space occupied by fuel})-(\text{Fuel volume})}{\text{Fuel surface area}}$$

These values of porosity were subjected to linear regression analysis with weight per unit of ground area as the independent variable.

Table 1.--Volume per gram and surface area per gram factors for components of cheatgrass

Plant parts	Observations	Volume per gram	Surface Area per gram
		$cm.^3/g.$	$cm.^2/g.$
Stalks	880	2.80	211
Leaves	50	3.98	662
Peduncles	100	1.96	541
Spikelets	5	1.74	560
Awns	20	1.88	560
Glumes	9	2.31	1,652

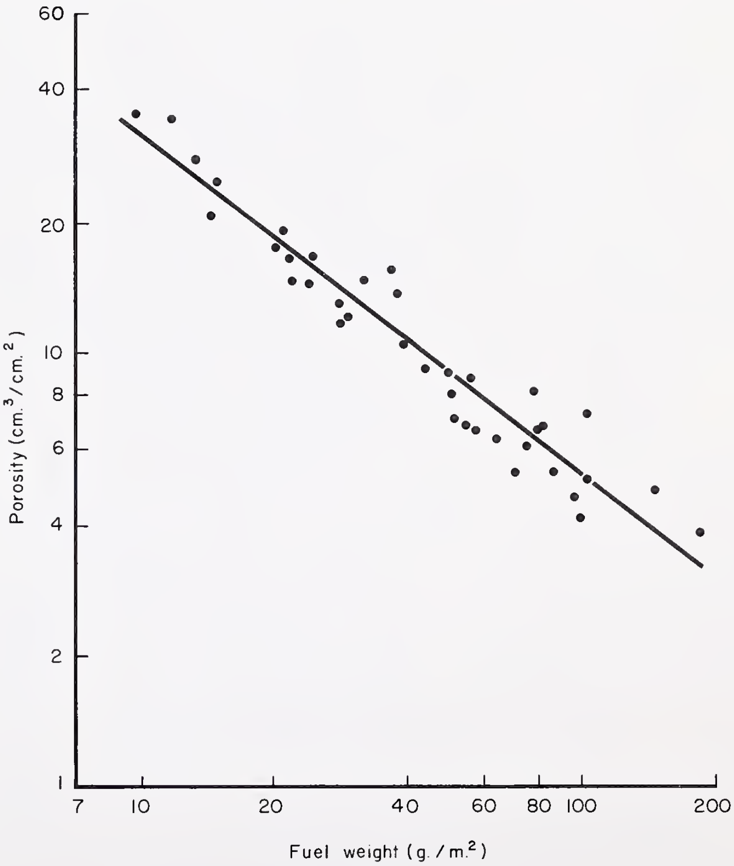
RESULTS AND DISCUSSION

The regression in figure 1 shows that for the cheatgrass studied, which averaged 16 cm. in height, porosity can be precisely estimated from fuel weight. Fuel weight averaged 53.1 ovendry grams per square meter (474 lbs./acre), and porosity averaged 12.5 $cm.^3/cm.^2$. Porosity is closely associated with weight because cheatgrass grows as an upright plant. As weight increases, the grass of a given height becomes more dense, and porosity thereby decreases.

Height of cheatgrass varies according to location and weather conditions during the growing season (Klemmedson and Smith 1964). Height growth exceeding 60 cm. has been recorded following a warm, rainy fall and spring (Stewart and Hull 1949). For cheatgrass taller than that studied, which had a maximum height of 25 cm., particle sizes and amounts of space occupied by fuel would produce different regressions. Possibly only the Y intercepts would change for larger material. Investigation of fuel weight and porosity over the possible size range of cheatgrass, with height as an added variable, should provide a relationship that allows porosity to be estimated from fuel weight and height for all cheatgrass.

As porosity increases, air and gases can move more freely because the distance between particles is generally greater. This tends to favor rapid burning. However, the distance that radiant heat must travel between particles is also greater, and this hampers burning. Some value, or within some value range of porosity, fuel ventilation and heat-transfer distance are in optimum balance for maximum rate of fire spread.

Figure 1.--Linear regression between fuel weight of cheatgrass and porosity. Log porosity = 2.2660 - 0.7706 (log weight) is the regression equation, significant at the 0.01 probability level, where r = 0.962 and standard error estimate equals 0.0710.



The precise relationship between porosity and flammability must be established before accurate evaluation of fire spread in cheatgrass is possible. Use of fuel weight (a variable related to forage production and easy to measure) to estimate porosity (a variable difficult to measure) is a practical aid in determining the flammability of cheatgrass. Estimation of porosity by this means could be a valuable step toward accurate evaluation of fire spread.

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